

CONTENTS

	Page
Abstract	1
Introduction	1
Materials and methods	2
Results and discussion	5
Conclusions	7
Acknowledgment	8

Illustrations

Fig.

1. Schematic of the modified ULV sprayer, showing how spray pesticides not deposited on corn plants are picked up and recirculated	2
2. Corn earworm damage on 'Ioana' sweet corn sprayed six times with ULV Gardona, with and without recycled droplets	6

Tables

1. Corn earworm damage on 'Ioana' sweet corn treated with various insecticide sprays	5
2. Insecticide recovered after ULV spraying with and without recycled droplets	7
3. Gardona buildup on 'Ioana' sweet corn after ULV spraying with and without recycled droplets	8

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CONTROL OF SPRAY DRIFT AND INSECTS IN SWEET CORN WITH AN ULTRA-LOW-VOLUME SPRAYER MODIFIED TO RECYCLE DROPLETS

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ABSTRACT

An ultra-low-volume sprayer was modified to collect and recycle insecticide spray droplets that were not initially deposited on plants in a stand of 'Ioana' sweet corn. The modified sprayer deposited about three times as much spray on the plants as the unmodified model, but corn earworm control was not significantly improved. The main advantage of recycling is to reduce the pesticide escaping into the environment; however, even with recycling, only about 10 percent of the sprayed insecticide could be accounted for.

INTRODUCTION

The use of ground sprayers designed to apply ultra-low volumes (ULV=<0.5 gallon per acre) of undiluted pesticides is becoming increasingly popular. Most such sprayers generate droplets small enough to become airborne and float away from the target area. One ULV sprayer developed by Agricultural Research Service engineers generates droplets with an average diameter of 29 micrometers.² The spray droplets are

fed into an airstream with a velocity of about 20 miles per hour for delivery to the target area. For crops such as corn, the sprayer is set to spray in a horizontal plane,³ and for crops whose outer canopy must be sprayed,⁴ it is set to spray in a vertical plane.

The corn sprayer was modified as described herein to trap spray droplets not deposited on the plants and recirculate them through the air system, to reduce contamination of the environment

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²Harrell, E. A.; Young, J. R.; Bowman, M. C.; and Hare, W. W. 1967. Insect control and residues in sweet corn using ground equipment for treating with low-volume formulations. *J. Econ. Entomol.* 60: 988-991.

³Harrell, E. A.; Hare, W. W.; and Sparks, A. N. 1970. Experimental ground equipment to apply concentrated dust and liquid pesticides for insect control on sweet corn. *J. Econ. Entomol.* 63: 382-385.

⁴Harrell, E. A.; Hare, W. W.; Womack, H.; and O Neil, J. B. 1970. Experimental ultra-low-volume ground equipment for insect control on cotton. *J. Econ. Entomol.* 63: 1074-1076.

by droplets that drift away from the target area.

MATERIALS AND METHODS

The ULV sprayer used in this series of tests generated spray droplets with a pneumatic atomizing nozzle, which was centered in a 3- by 4-inch air nozzle (fig. 1). The nozzles were mounted on the sprayer to pass about 12 inches from the row, spraying horizontally across the row. A rectangular sheet-metal transition (6 by 11 by 14 inches) was built and mounted on the sprayer, across the sprayed row directly in front of the nozzles. Two di-

viders were placed inside the transition to equalize air movement across its length (14 inches). The transition, connected to the fan inlet by a 6-inch-diameter flexible hose, became the new air intake. Spray droplets not deposited on the plants were picked up by the air currents and carried into the air intake. The new intake was designed either to trap the droplets in a filter or to let them pass through the fan and be recycled. In preliminary testing the droplets were trapped, but in the test described here they were recycled.

The spray from the nozzles was emitted in a continuous uniform pattern aimed at the target (corn

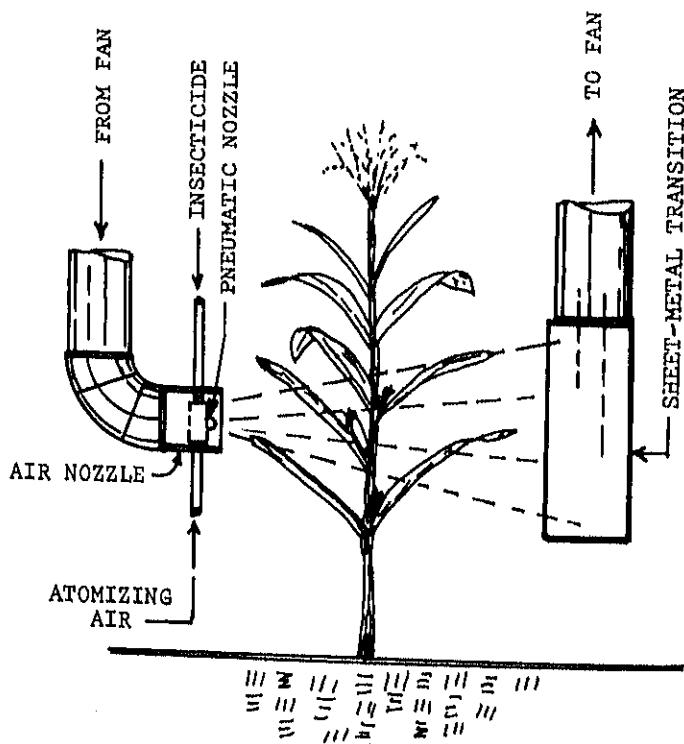


FIGURE 1.—Schematic of the modified ULV sprayer, showing how spray pesticides not deposited on corn plants are picked up and recirculated.

plant). For a corn plant to capture all spray droplets, it must cover all the area in a plane perpendicular to the spray pattern. Estimates of the area covered were made by placing a sheet of plywood ruled with a 2- by 2-inch grid behind a plant and counting the number of squares covered. The coverage of partially covered squares was estimated. The plants were spaced 12 inches apart in the drill row, so a 12-inch-wide area of the grid times the height of the plant was used in making the estimate. All foliage from the plant selected, as well as adjacent plants that might have foliage covering the grid, was counted. A sample of five 'Ioana' sweet corn plants at the optimum roasting ear stage, selected and counted by three persons, was replicated three times. An entire plant in these tests covered about 24 percent of the area; thus, only 24 percent of the droplets sprayed could be expected to strike plant surfaces. The remaining 76 percent of the droplets could pass through the foliage and strike other plants or drift away, thus presenting an environmental contamination hazard. (These conditions prevail only if the droplets are uniformly emitted horizontally from top to bottom of a plant and if each droplet strikes a plant at the first opportunity.) The ULV sprayer covered a swath about 12 inches high at the plant. With an ear tip as the center of the spray swath, about 33 percent of the grid area was covered by foliage. Extending the spray zone to 18 inches instead of 12

inches did not increase the percentage of foliage falling within the spray zone. Thus, using the ULV sprayer emitting droplets aimed at the ear zone, one would expect not more than one-third of the droplets to strike a corn plant.

'Ioana' sweet corn, the test crop, was planted in rows 80 feet long by 38 inches wide. Plot widths were 25 and 6 rows wide for studying drift and insect control, respectively. Each insect control treatment was replicated four times. Gardona, 2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate, was the primary test pesticide used in all phases of the test. Carbaryl and malathion were used in the conventional equipment only.

Spraying for insect control was begun when the corn plants were about 10 percent silked and continued on a Monday-Wednesday-Friday schedule until six treatments had been made. In the drift tests the spray nozzles were directed as nearly as possible toward the middle of the plants, or about 25 inches above the ground. Gardona used in the drift studies was applied at 39 milliliters per minute (3.2 pints per acre). At the time of spraying for the drift study, the temperature was 80° F dry bulb and 70° F wet bulb. The wind was blowing from the south-southwest at 0 to 8 miles per hour across the rows, which ran about north and south.

Drift samples were taken by randomly selecting eight plants from each sample row and dividing them into three sections—tas-

sel, top third of the plant; ear, middle third of the plant; and base, bottom third of the plant. Sample rows were the spray rows and rows 1, 3, and 7 on each side of the spray row.

The soil was sampled by taking 15 samples on the sprayer side of each sample row, with a probe made of 1-inch stainless steel pipe fitted with a depth gage so that the same volume of soil would be obtained for each sample. As soon as samples were obtained, they were placed in plastic bags, carried to the laboratory, weighed, and placed in a freezer.

Two groups of samples were taken for residue determinations—one to determine pesticide drift from spraying with and without recycled droplets, and the other, from the insect control plots, to determine residue buildup from successive sprayings. These samples were taken after the first, third, and sixth application of pesticide. Insect control plots used for residue samples were replicated three times.

The Gardona residue was extracted and analyzed.⁵ The base, ear, and tassel samples were chopped separately into fine particles in a Hobart food chopper; then 100 grams of each sample was added to a Waring Blender containing 100 grams of anhydrous sodium sulfate and 300 milliliters of benzene, and blended for 5 minutes. The benzene extract was filtered through What-

⁵Beroza, M., and Bowman, M. C. 1966. Gas chromatographic determination of photometric detection. *J. Agric. Food Chem.* 14(6): 625-627.

man No. 1 filter paper and stored in bottles over sodium sulfate.

One-hundred fifty milliliters of the extract (equivalent to 50 grams of crop) was concentrated to the appropriate volume for gas chromatographic analysis. An F&M Scientific Corporation (Avondale, Pa.) model 700 gas chromatograph, equipped with a Melpar flame photometric detector operated in the phosphorus mode (526-nanometer interference filter), was used for the analysis. The chromatography was carried out on a glass column, 100 centimeters by 4 millimeters inside diameter, packed with 10 percent OV101 on Gas Chrom Q (Applied Science, Inc., State College, Pa.) and maintained at 180° C. The injection port and detector temperatures were 200° and 225° C, respectively. Gas flows were as follows: nitrogen (carrier)—160 milliliters per minute; oxygen—40 milliliters per minute; and hydrogen—200 milliliters per minute.

The column was conditioned overnight at 180° C and further conditioned by injection of corn extract and insecticide until the latter gave a constant response. The unknowns were injected (5 microliters) and quantitated by comparing peak heights with those of a standard which was injected frequently.

Insect damage was evaluated on 150 ears per treatment when the ears were at the optimum roasting ear stage. A damage scale of 1 to 5 was used: 1—no damage; 2—silk damage only; 3—damage from tip to a depth of 0.5 inch;

4—damage extending from 0.5 to 1.0 inch from the tip; and 5—damage more than 1.0 inch from the tip.

RESULTS AND DISCUSSION

Insect control did not differ significantly when a ULV sprayer was used with and without the recycling device and when pesticide was applied at the same rate (table 1). With both ULV sprayers there was a trend toward fewer worm-free ears than were obtained with a conventional sprayer. The quantity and type of pesticide influenced the degree of insect protection. No significant differences in insect control were obtained with carbaryl, Gardona, and malathion at equivalent rates. However, plots treated with Gardona at 1 pint per acre produced fewer worm-free ears than those treated with 2 and 4 pints per acre.

There were large differences

in the number of worm-free ears in the two tests in untreated plots. Treated plots also had fewer worm-free ears as insect pressure increased. The best combinations of insecticide, quantity, and application techniques produced 97 and 68 percent worm-free ears when the control plots showed 43 and 10 percent worm-free ears, respectively. Additional work is needed to improve insect protection when the pressure is heavy. Plots used for determining pesticide buildup on the plants from ULV spraying were also sampled for insect control (fig. 2). Insect pressure was not high on these plots; however, treated rows produced 90 and 83 percent worm-free ears when sprayed with the ULV with and without recycled droplets, respectively. There was an average of 65 to 75 percent worm-free ears on rows adjacent to the sprayer rows. The number

TABLE 1.—*Corn earworm damage on 'Ioana' sweet corn treated with various insecticide sprays*
[6 insecticide applications, Monday-Wednesday-Friday schedule]

Sprayer	Spray rate per acre		Insecticide	Worm-free ears ¹ (percent)	
	Volume	AI (lb)		Test 1	Test 2
Conventional	25 gal	1.0	Carbaryl	97a	....
Do	25 gal	1.0	Gardona	95a	68a
Do	25 gal	2.0	Malathion	62abc	
Do	25 gal	2.0	Gardona	57abc	
ULV (recycled droplets)	4 pt	1.0	..... do	92a	61ab
Do	2 pt	.5	..... do	.....	54abc
Do	1 pt	.25	..... do	.....	45bc
ULV (unmodified)	4 pt	1.0	..... do	89a	66ab
Do	2 pt	.5	..... do	.....	67ab
Do	1 pt	.25	..... do	.....	38c
Experimental corn sprayer ²	25 gal	1.0	..... do	91a	.....
Control	.....	.....	.....	43b	10d

¹ Means of 150 ears per replication. Means followed by the same letter are significantly different at the 0.05 level by Duncan's multiple-range test.

² The same sprayer mechanics as the conventional sprayer except the dry insecticide was metered into the carrier and mixed concurrently with spraying.

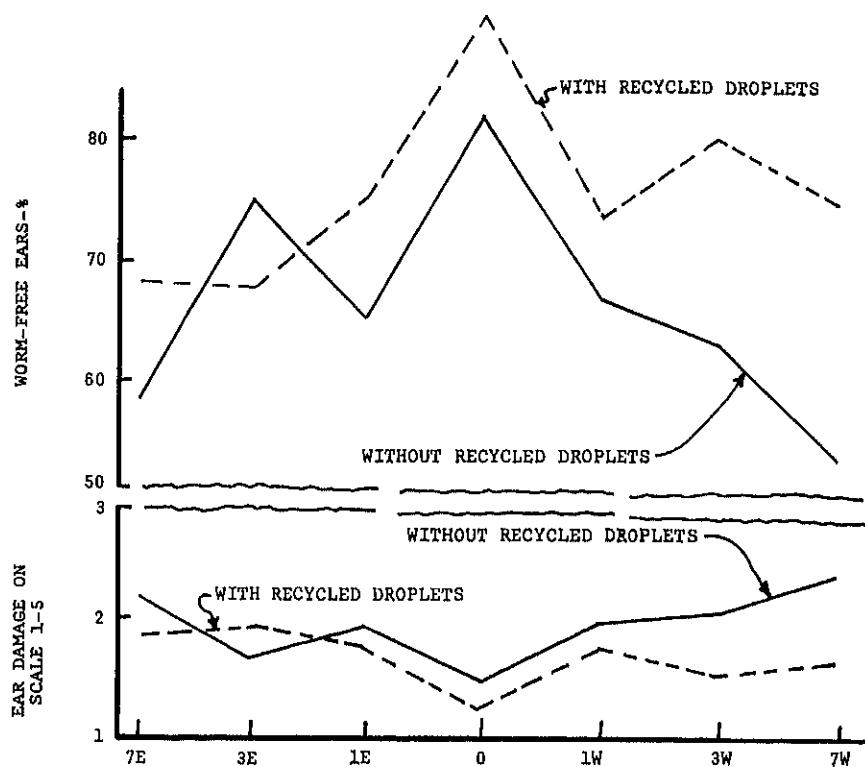


FIGURE 2.—Corn earworm damage on 'Ioana' sweet corn sprayed six times with ULV Gardona, with and without recycled droplets. 0 = spray row, 1E = 1st row east of spray row, 1W = 1st row west of spray row, etc.

of worm-free ears on rows farthest from the sprayer rows was more erratic. The rows on the west side (rows running north and south) of the spray row produced slightly more worm-free ears when sprayed with the ULV with recycled droplets. Difference in worm-free ears from rows on the east side of the spray row was less noticeable. The nozzle was spraying toward the west, which should have allowed more drift onto the rows west of the spray row. However, wind currents (0-8 miles per hour) were from the south-southwest, which

may have helped to counteract drift to the west rows.

The quantity of pesticide deposited on the plants was 9.2 percent of the amount sprayed with the ULV sprayer with recycling, and 3.6 percent without recycling of droplets (table 2). The ear zone, which was the target, received 592 micrograms per plant, or about 2.2 percent of the spray emitted with the ULV sprayer, while about one-half this amount (357 micrograms) was found on the upper third and only 7 micrograms was found on the bottom third of the plant. The soil con-

TABLE 2.—*Insecticide recovered after ULV spraying with and without recycled droplets*

Sample	Residue, unmodified ULV spraying		Residue, ULV spraying with recycled droplets	
	Micrograms per sample	Percentage of insecticide applied	Micrograms per sample	Percentage of insecticide applied
Corn plant:				
Base	7.40	0.03	109.76	0.40
Ear	591.96	2.24	1,751.46	6.64
Tassel	357.60	1.36	561.42	2.13
Total	958.96	3.63	2,422.64	9.17
Soil	9.16	1.33	7.33	1.07
Total ¹ .....	.....	4.96	.....	10.24

¹ This total represents the amount of sprayed pesticide accounted for. The remaining material presumably drifted away.

tained 1.8 percent of the pesticide sprayed. When the droplets were recycled through the sprayer, about 1,750 micrograms per plant was deposited on the ear zone (middle third of the plant) and about a third of this amount on the top third of the plant. The bottom third of the plant received less than 0.5 percent of the total pesticide sprayed. The soil contained 1.1 percent of the pesticide sprayed, which indicated that a major portion of the pesticide had moved upward and drifted away.

Table 3 gives a sampling of the results of repeated applications used for insect protection. These data confirm that more pesticide was deposited on the plant when the ULV sprayer was equipped to recycle the spray droplets. Residue samples from the spray row (row 0) show that pesticide was persistent in that the buildup on the plant was proportional to the number of applications, with or without recycling. Adjacent rows

on either side of the spray row had no definite pattern in residue buildup. Other rows sampled showed insignificant amounts of pesticide deposited on the plants.

CONCLUSIONS

The ULV sprayer equipped to recycle droplets not initially deposited on plants resulted in a threefold increase of pesticide deposit, but insect control was not significantly different when the same pesticide was used in the two ULV sprayers. The small insect-control differences are probably due to effectiveness of the pesticide. However, it should be noted that as insect pressure increased the number of worm-free ears decreased. If the quantity of pesticide was adequate, then the reduction in worm-free ears under increased pressure must have resulted from timing and placement of the pesticide on the new silks. Further work should be un-

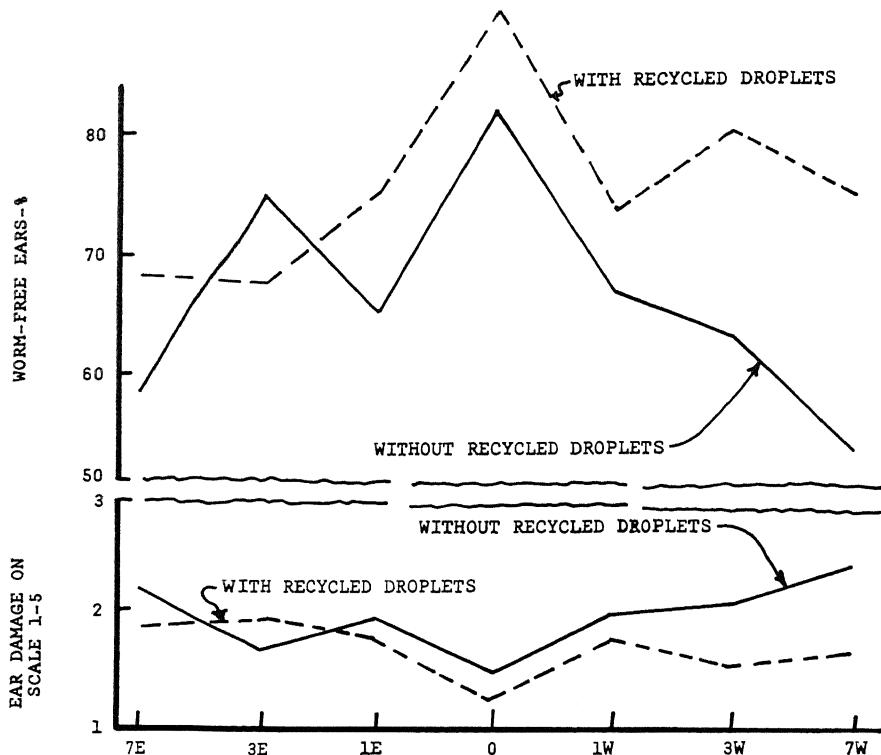


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dertaken to learn how these factors operate.

A user of materials and equipment as described herein may expect to lose about 90 percent of the pesticide sprayed. We were able to account for only 10.24 percent of the amount sprayed. When spraying a large area, the amount deposited would probably increase because of filtering of the pesti-

cide from the air by the plant foliage.

ACKNOWLEDGMENT

We express appreciation to J. H. Martin and F. G. Crumley, Southern Grain Insects Research Laboratory, Agricultural Research Service, for their valuable assistance in completing this study.

TABLE 3.—*Gardona buildup on 'Ioana' sweet corn after ULV spraying with and without recycled droplets*
[Monday-Wednesday-Friday spray schedule]

Row ¹	No. of applications	Droplets recycled?	Gardona buildup (micrograms)		Percentage of sprayed material deposited on corn ears
			Total sample	Per plant	
0	1	Yes	14,408.40	600.35	2.26
0	3	Yes	45,215.16	1,883.96	7.08
0	6	Yes	52,181.33	2,172.14	8.17
0	1	No	5,154.40	.214.8	.81
0	3	No	26,380.06	1,099.17	4.13
0	6	No	26,073.66	1,086.40	4.08
1E	1	Yes	140.12	.5.84	.022
1E	3	Yes	50.49	.2.10	.008
1E	6	Yes	418.57	17.44	.066
1E	1	No	96.97	.4.04	.015
1E	3	No	85.23	.3.55	.013
1E	6	No	395.55	16.48	.062
IW	1	Yes	31.39	.1.33	.005
IW	3	Yes	258.32	10.76	.040
IW	6	Yes	222.11	9.25	.035
IW	1	No	37.6	.1.57	.006
IW	3	No	369.48	15.39	.058
IW	6	No	237.23	9.88	.037
3E	1	Yes	110.37	4.59	.017
3E	3	Yes	51.08	2.13	.008
3E	6	Yes	188.42	7.85	.030
7E	1	Yes	21.71	.90	.003
7E	3	Yes	166.31	6.93	.026
7E	6	Yes	96.71	4.03	.015

¹ 0=spray row, 1E=1st row east of spray row, 1W=1st row west of spray row,
3E=3d row east of spray row, 7E=7th row east of spray row.

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